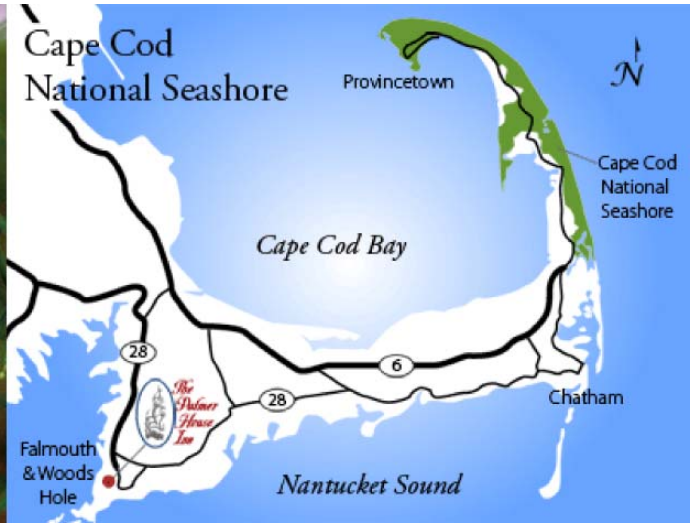
Sandplain Gerardia (*Agalinis acuta*) and Cape Cod National Seashore



Contents

Exercise 2.1: Assessing Sensitivity

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group
Output: Sensitivity checklist

We want you to gain experience identifying and articulating components of sensitivity for species, habitats, and ecosystems. You may find yourself distracted by the question of whether a particular characteristic is a component of sensitivity, exposure, or adaptive capacity; in the end it doesn't matter which bin you put characteristics into. What matters is that you understand how particular characteristics contribute to vulnerability or lack thereof.

Steps:

I. You will be working in groups of 6-8 people around a table. Each table will have a packet of information for Exercises 2.1, 2.2, and 2.3. This packet will include a variety of maps related to a particular species and administrative unit.
II. Examine the sensitivity checklists (species and administrative unit; based on Josh Lawler's Climate Sensitivity Database).
III. Work through the sensitivity checklist for one species and one place to provide an overall estimate of sensitivity as well as a list of factors that contribute to the relative sensitivity of the species and unit. Information on your species and administrative unit has been provided in the packet to help you develop a rank for sensitivity.
IV. We will take time at the end of the exercise to hear back from groups about their results.

Your assigned species will be clear from your packet's cover page. Below we have suggested species/administrative unit pairings (like fine wine and cheese), but you may opt to assess any administrative unit within your species' range if you have access to a computer and wish to look up information on your own.

1. **Species:** Foothill Yellow-legged Frog (*Rana boylii*): aquatic frog of California - BC; **Admin unit:** Umpqua-Klamath National Wildlife Refuge
2. **Species:** Greater Sage Grouse (*Centrocercus urophasianus*); **Admin unit:** Humboldt-Toiyabe National Forest
3. **Species:** Sandplain Gerardia (*Agalinis acuta*): annual plant occurring on disturbed sandy soils in Northeast USA, federally listed; **Admin unit:** Cape Cod National Seashore

Resources:

I. Species climate change sensitivity checklist
II. Place/habitat climate change sensitivity checklist
III. Species information (e.g., distribution, natural history, ecology)
IV. Place/habitat information (e.g., site description, dominant vegetation, management structure)

Species Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the species to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Generalist or specialist
Is the species more of a generalist or a specialist?

Generalist				Specialist
1	2	3	4	5

3. Disturbance regimes
How sensitive is the species likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Interspecific interactions
How sensitive are key interspecific interactions to climate change (e.g., competitive relationships, predator prey relationships, diseases, parasites)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sensitive habitats
Does the species rely on habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not dependent				Highly dependent
1	2	3	4	5

6. Non-climatic stressors
To what degree is the species negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted				Severely impacted
1	2	3	4	5

Place/Habitat Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the dominant vegetation type to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Place/ecosystem size
Is the administrative unit dominated by a single ecosystem/ habitat type, or does it encompass a range of climates and ecosystems?

Broad range				Single ecosystem
1	2	3	4	5

3. Disturbance regimes
How sensitive is the administrative unit likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Individual species sensitivities
How sensitive are key species in the administrative unit to climate change (e.g., flagship species, ecosystem engineers, keystone species)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sensitive habitats
Does the administrative unit contain (or is it characterized by) many habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not many				Many
1	2	3	4	5

6. Non-climatic stressors
To what degree are the habitats in the administrative unit negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted				Severely impacted
1	2	3	4	5

Sandplain Gerardia – Summary information

Natural History (NatureServe 2011)

- *Agalinis acuta* is an annual hemiparasitic herb. Its populations are dependent on seed production for continued survival. The germination and early growth of *A. acuta* has not been monitored in natural populations.
- It occurs on dry, sandy, short grass plains, roadsides, and openings in oak scrub.
- The soils supporting *A. acuta* are nutrient-poor, usually acidic, and excessively drained.
- Flowering in Massachusetts occurs between August 20th and September 30th, the peak being the first week of September. Phenology of bloom has not been studied in Maryland populations, but flowering has been observed in early September. Time of anthesis has been difficult to establish. The majority of fresh flowers have been observed in the morning, many dropping off by mid-afternoon. Maturation of plants continues well into October.
- It has been estimated that it has 0-29 fruits per plant, with a median of 8 and mean of 9.
- Mode of seed dispersal is unknown. If wind dispersed, seeds are not likely to travel far. Some dispersal may occur through ingestion by small animals such as meadow voles (*Microtus pennsylvanica*) or cottontail rabbits (*Sylvilagus spp*.).
- Means of pollination are unknown, but fruit set at known sites suggests that pollination is not a problem. A fly observed at one Massachusetts site was tentatively identified as *Toxomerus marginatus*, a common member of Syrphidae inhabiting salt marshes. Because adults of this species are known to feed on 200 plant species, it is not considered to be an effective pollinator.
- Although seed exposure to cold is not necessary for germination, a cold period appears to be beneficial. However, the population of plants grown under these conditions was not robust. A number of factors may have been responsible for the generally poor condition of the surviving plants, including the absence of a host species. The role of parasitism in the life cycle of *A. acuta* needs further investigation.
- Populations of *Agalinis acuta* can fluctuate widely from year to year. Although a reduction is cause for concern, fluctuation in numbers might be a natural phenomenon in *A. acuta*. Cutting of flowering stems does not necessarily preclude seed production, however. If severing occurs above the lowest axillary stems, the plant can produce new shoots that will successfully flower.
- The two extant sites supporting *A. acuta* in Massachusetts occur in small cemeteries on Cape Cod. Soils are sandy, and the grassland vegetation has probably been mowed regularly for over 100 years. Both are historic cemeteries with gravestones dating to the 1700's. The grassland openings are less than 1/2 acre in size, and surrounding vegetation is predominantly *Pinus rigida* and *Quercus alba* woodland.

Disturbances (NatureServe 2011)

- There is evidence of grazing on almost all of the plants (in a population of 1000-2000 plants) at Long Island site 4; herbivory was also noted at both Massachusetts populations.
- Dependent on periodic disturbance that maintains an open habitat. On-going disturbances at extant sites include mowing, fire, and use of a horse trail, which periodically exposes new soil. Historically, grazing was a common disturbance factor in areas where the species occurs. Grassland communities supporting *A. acuta* are typically dominated by one or more of three grasses: little bluestem (*Schizachyrium scoparium*), Virginia broomgrass (*Andropogon virginicus*), or Indian grass (*Sorghastrum nutans*).

- Small fires, topsoil scarification, and other forms of human activity have occurred on all the Long Island sites except site 6, where use of a horse trail periodically exposes new soil for colonization. Most of the *Agalinis* plants occurring within the Maryland serpentine barren are also found on disturbed soils.
- Fire has played a role in maintaining open habitat.
- Proximity to the ocean imposes an additional stress of salt spray.

Known climate change responses

- Coastal populations face serious threats from severe storms that can cause wind scouring, salt spray damage, and overwashing or erosion of habitat by waves (NatureServe 2011).

Comments on the species conservation status and threats

This species has several factors working against it. It requires frequent disturbance, such as that provided by burning, mowing or perhaps grazing, to maintain its early successional habitat conditions. Once dense cover or heavy litter builds up the species is apt to disappear. Despite being an annual that produces abundant seed, data from Massachusetts studies suggest that it typically disperses seed only over short distances (maximum of 3.5 m from previous year plots) and only seedbanks for short durations (up to 4 years only perhaps). It is also vulnerable to seed predation by insects, especially when populations become dense (NatureServe 2011).

Cape Cod National Seashore - Summary Information

Basics

Cape Cod is a large peninsula extending 60 miles into the Atlantic Ocean from the coast of Massachusetts. Located on the outer portion of the Cape, Cape Cod National Seashore's 44,600 acres encompass a rich mosaic of marine, estuarine, fresh water, and terrestrial ecosystems. These systems and their associated habitats reflect the Cape's glacial origin, dynamic natural processes, and at least 9,000 years of human activity. Geomorphic shoreline change, ground water fluctuations, tidal dynamics including rising sea level, and atmospheric deposition are among the many physical processes that continue to shape the Seashore's ecosystems. Marine and estuarine systems include beaches, sand spits, tidal flats, salt marshes, and soft-bottom benthos. Freshwater ecosystems include kettle ponds, vernal pools, sphagnum bogs, and swamps. Terrestrial systems include pitch pine and scrub oak forests, heathlands, dunes, and sandplain grasslands. Many of these habitats are globally uncommon and the species that occupy them are correspondingly rare.

Cape Cod National Seashore harbors a diverse array of terrestrial, wetland, aquatic, and marine plants that are uniquely adapted to life in the coastal environment. More than 800 species comprise the vascular flora of the seashore, which are associated with a number of landscape features. For example, heathlands, grasslands, dunes, woodlands, forests, vernal pools, kettle ponds, salt marshes, freshwater marshes, intertidal zones, and seagrass beds are among the different community-types that can be distinguished by their own special kinds of plant life.

Species

Both Massachusetts' *A. acuta* populations occur in *Schizachyrium scoparium*-dominated sites; associated species common to both sites include *Arctostaphylos uva- ursi*, *Vaccinium angustifolium*, *Agrostis hyemalis*, *Aira praecox*, *Danthonia spicata*, *Festuca rubra*, *Carex emmonsii*, *Cerastium vulgatum*, *Gnaphalium obtusifolium*, *Helianthemum canadense*, *Hieracium venosum*, *Hypericum gentianoides*, *Polygala polygama*, *Potentilla canadensis*, *Spiranthes gracilis*, *S. tuberosa*, *Viola pedata*, *Aster paternus*, *Panicum sphaerocarpon*, *Aster linariifolius*, and *Aster undulates*.

Broom crowberry (*Corema conradii*) is a regionally endemic plant that is found in coastal sandplain communities from New Jersey to Newfoundland. It is listed as a Species of Special Concern by the state of Massachusetts. Cape Cod has long harbored some of the largest and best known populations of broom crowberry, with descriptions by early settlers depicting carpets of the plant and healthy seedling recruitment. Unfortunately, many of the populations on Cape Cod and the surrounding islands are aging and it is unknown if recruitment is sufficient to maintain these populations.

Over 450 species of amphibians, reptiles, fish, birds, and mammals, and a myriad of invertebrate animals, depend on the diversity of upland, wetland, and coastal ecosystems found at Cape Cod National Seashore. Depending on the species, the park may provide habitat year round, or only during nesting season, migration, or the winter time.

Key issues

Sea-level rise, acid rain, ozone, groundwater withdrawal, nutrient enrichment, and invasions of exotic species are just a few of the threats that pose serious risks to plant diversity and ecological function across the landscape at Cape Cod National Seashore.

Disturbances: Estuaries and salt marshes are some of the most biologically productive ecosystems in the world serving as a source of nutrients for many coastal food chains as well as habitat and feeding grounds for an array of important species. Like many coastal areas in the United States, the land use history pertaining to estuaries and salt marshes on Cape Cod has proven destructive. In past centuries much of the intertidal acreage on Cape Cod has been restricted or drained as what were once common means of mosquito control. Due in large part to this fact, salt marsh restoration is a major focus of current management and research at Cape Cod National Seashore.

Loss of upland habitat to development, wetland draining and filling, pesticides, acid deposition, road mortality, diseases, and introduced competitors and predators have all been implicated in amphibian declines in Cape Cod National Seashore.

Disturbance by humans in the form of foot or vehicle traffic re-sets the successional sequence. In terms of natural processes, animals such as rabbits and deer play a role in the dispersal of seeds through the system. The presence of *Morella pensylvanica* (northern bayberry) can facilitate the establishment and growth of other plants through its ability to fix atmospheric N, which is eventually incorporated into the soil through litterfall and decomposition

The suppression and disruption of historical disturbance has resulted in conversion of the early-successional community types to other later-successional community types like shrubland and forest. The long term status of the existing grasslands and heathlands is uncertain. In addition to being themselves rare, these communities serve as important habitat for a host of vulnerable wildlife, notably open land birds including the Vesper Sparrow (*Pooecetes gramineus*) and Grasshopper Sparrow (*Ammodramus savannarum*).

Invasive species: Monitoring of tidal restoration projects has shown that re-starting seawater flow in systems that had been diked (or in some other way cut off from normal tidal exchange) can rapidly promote the spread of native salt marsh plants. Furthermore, increased tidal exchange has dramatically reduced or shifted the distribution of non-native, highly invasive taxa like *Phragmites australis* (common reed) and *Lythrum salicaria* (purple loosestrife) (Smith 2009).

Climate change: Cape Cod's climate is changing, and records show that winters are shorter and summers are hotter and longer. As with many ecosystems within Cape Cod National Seashore, kettle ponds are susceptible to climate-related changes in air temperature, precipitation, and sea level, which drive physical, chemical and biological processes. Gull Pond, the largest and deepest kettle pond in the park, has been monitored by National Park Service natural resource staff for decades to study what its history reveals about changes in the climate and the environment, as well as assess the impact of current human use. It covers 44 hectares, with an average depth of 10 meters and a maximum depth of 20 meters. Gull Pond has also been the subject of paleolimnologic research that documented the influences of climate, physical setting and human activities on its modern water quality and biology. Data obtained by Cape Cod Ecosystem Monitoring staff shows that average surface water temperature at the warmest time of year has been increasing since 1980. This increase in pond water temperature

over time is likely related to higher air temperatures associated with atmospheric warming (Fox et al. 2009).

General climatic factors such as precipitation and temperature influence dune communities. Prolonged drought should create or maintain early successional communities while periods of high precipitation will promote the development of later stages (Smith 2005).

References

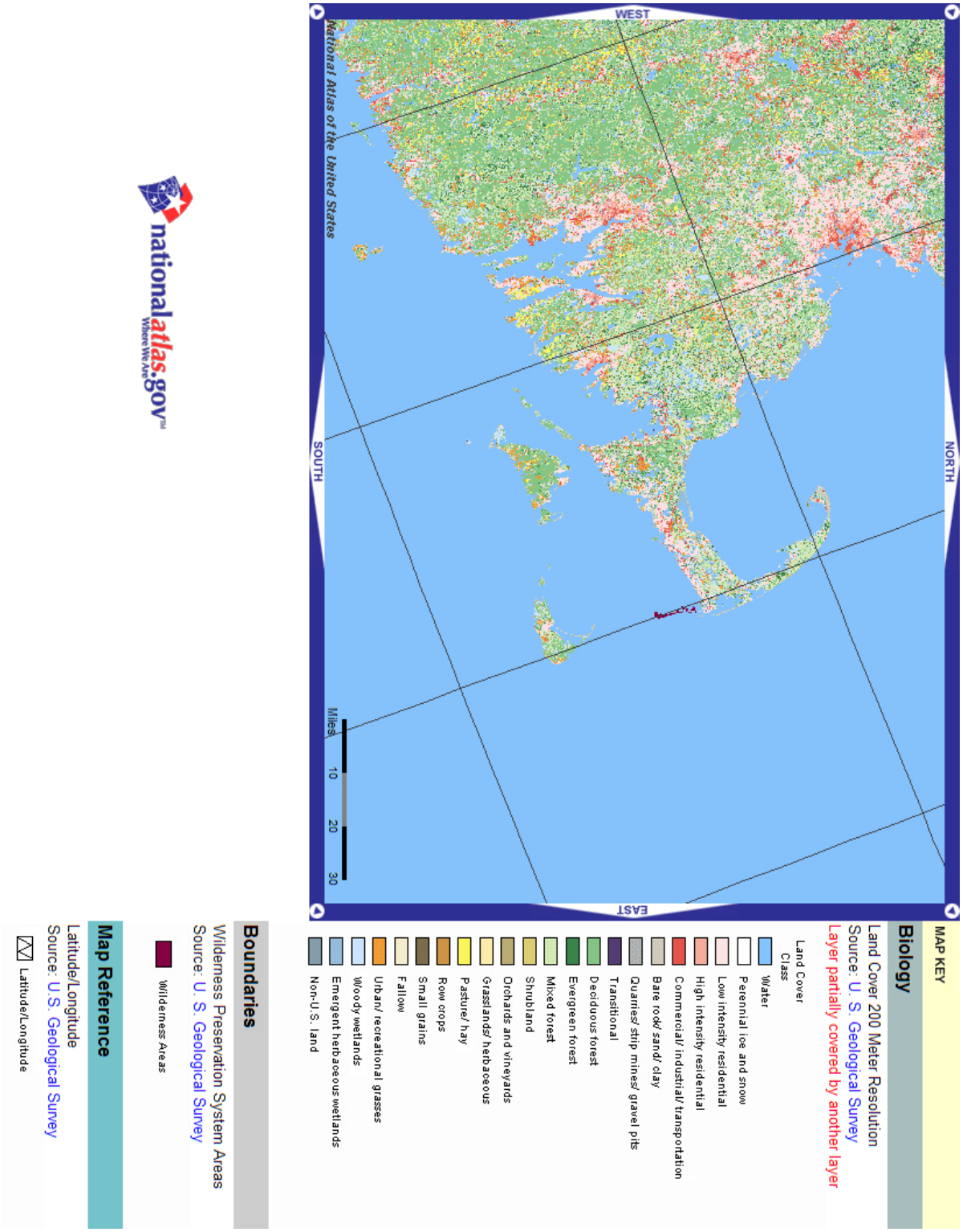
Fox, S., S. M. Smith, R. Cook, K. Medeiros, H. Bayley, and M. Tyrrell. 2009. Monitoring Climate Change at Cape Cod National Seashore. Brief, Cape Cod National Seashore, National Park Service, US Dept of Interior, Wellfleet, MA.

NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Retrieved December 27, 2011, from http://www.natureserve.org/explorer.

Smith, S. M. 2005. Dune vegetation monitoring, 2005. NPS Report, Cape Cod National Seashore, National Park Service, US Dept of Interior, Wellfleet, MA.

Smith, S. M. 2009. Salt Marsh Vegetation Monitoring. Brief, Cape Cod National Seashore, National Park Service, US Dept of Interior, Wellfleet, MA.

Cape Cod National Seashore Land Cover



Exercise 2.2: Assessing Exposure

Length: 60 minutes

Lead-- All instructors needed to help groups
Format: small group

Output: A discussion of exposure for your species and your administrative unit The goal of the questions below is to get you thinking about what elements of exposure are most important for assessing the vulnerability of the particular species, habitats, or places with which you are concerned. The metrics of change most commonly presented in the media—e.g. changes in average global or regional temperature and changes in average global or regional rainfall—aren't always the most appropriate metrics for a particular VA.

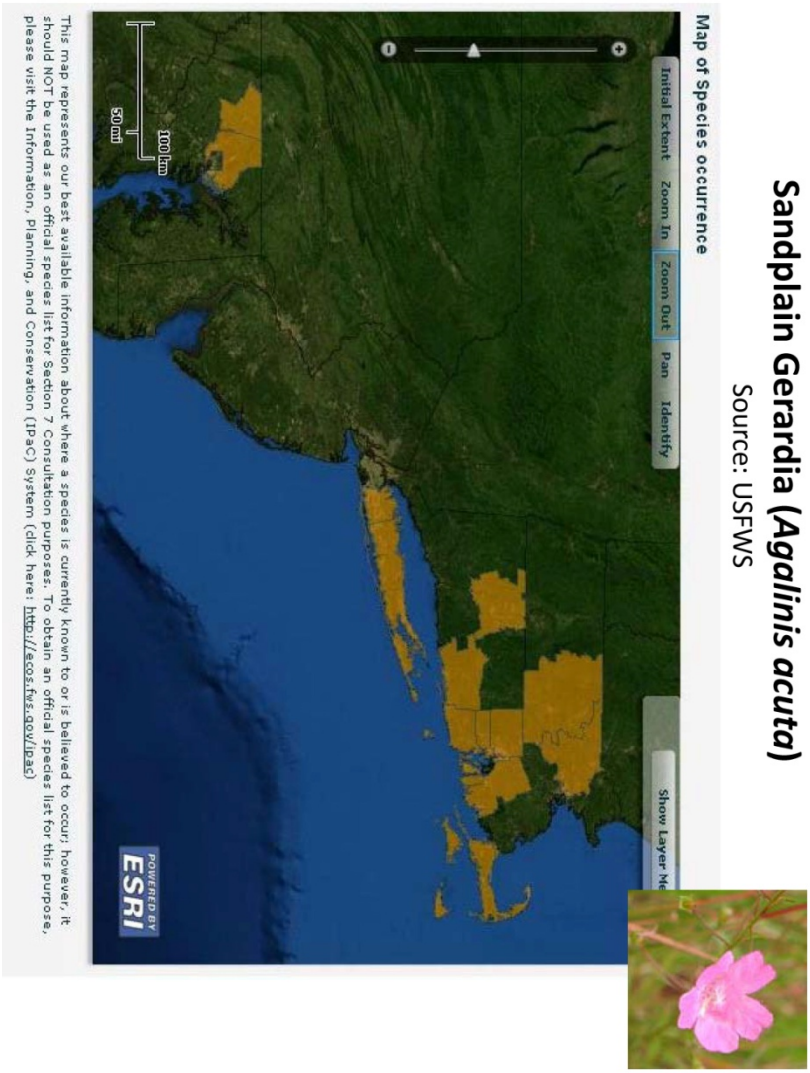
Resources:

I. Range (for species) or boundaries (for habitat/administrative unit)
II. Shaded relief map for relevant area (created using the National Atlas; can go to nationalatlas.gov and look in the geology layer if you want to zoom in)
III. Maps of projected changes in various climate variables for the relevant area.

Questions to consider:

1. What elements of exposure are likely to be most relevant or important for the species in question? For the habitat or administrative unit? (NOTE: there may be elements that are in the "most relevant" category that have not been provided to you in the packet. List any layers missing that you think would help you better evaluate exposure).
2. For species: What factors are most important in determining the species' range? Think not just about climate variables, but about other factors as well (e.g. presence of particular plants, absence of particular competitors, etc.). How might this influence the variables on which you chose to focus?
3. For administrative units: What are the goals, vision, or mandate for this administrative unit? What factors are most important in determining the ability of the unit to meet these goals, vision, and mandates?
4. What factors might influence exposure? That is, what factors influence the actual amount of climatic change experienced by the species or place in question? For example, some types of air pollution reflect heat and thereby slow warming; type and density of plant cover can influence heating, cooling, moisture, and fire regime.
5. How would you express exposure for the species in question—maps of each variable separately? Of only the most important variables? A combined map showing average change in all variables? A single ranking or score for exposure across the entire range/unit? Exposure maps or scores for a few key species or habitat types within the administrative unit? Think about various ways you might want to use the VA results and how different ways of expressing exposure (and ultimately overall vulnerability) might be better or worse for each type of use.

Sandplain Gerardia Range Map

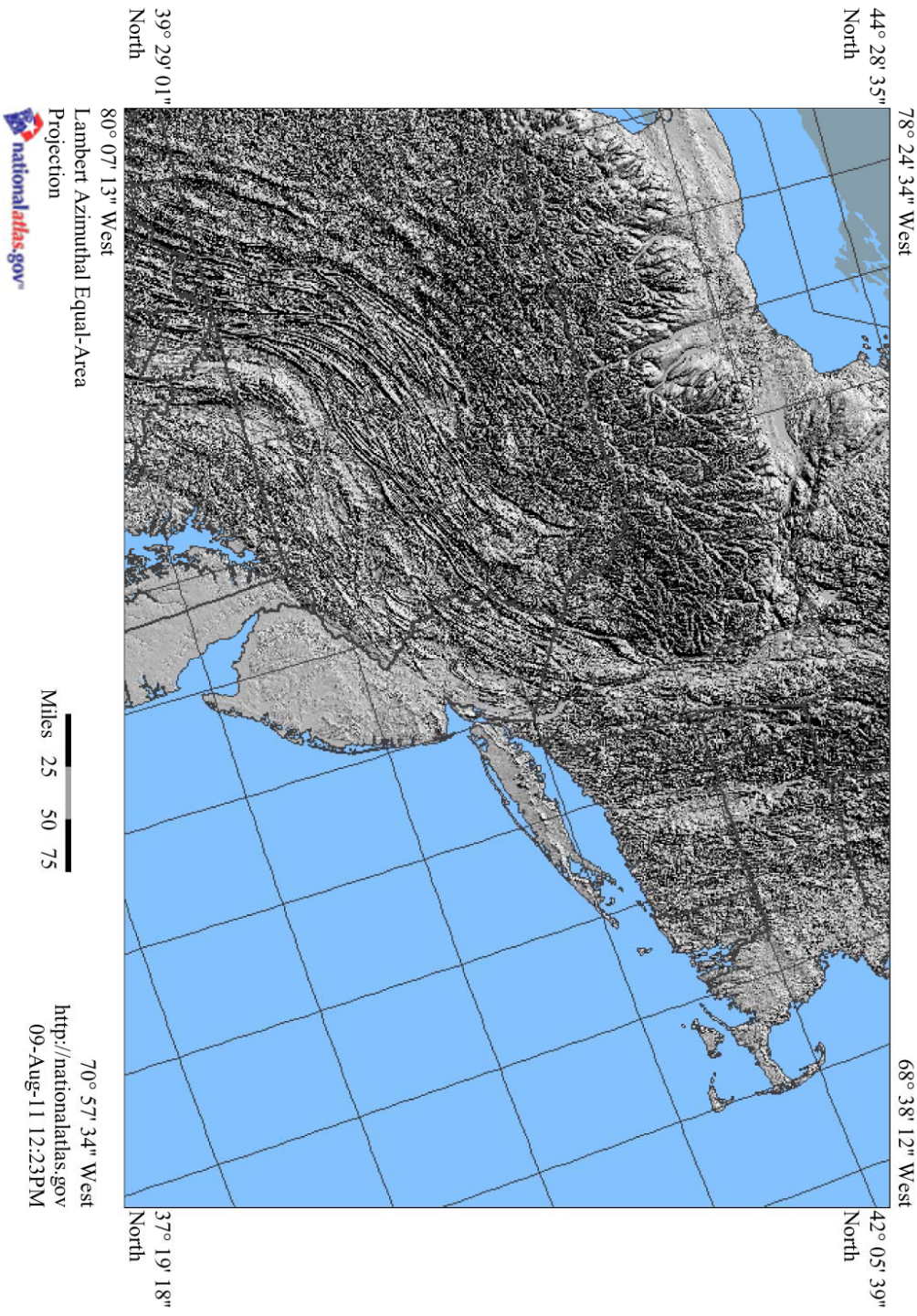


Agalinis acuta is known historically from five states: Connecticut, Rhode Island, Massachusetts, Maryland, and New York. It is primarily a species of the Coastal Plain, but in Maryland exists on the Piedmont. Connecticut is known to have supported two populations, but now has one small population in a cemetery. Rhode Island harbored six populations, including one "on a sandy plain between Lime Rock and the Blackstone River", and now has a single remnant population in a cemetery. Massachusetts once supported populations ranging from Nantucket, Marthas Vineyard, upper Cape Cod and at a few disjunct inland locations to Worcester County; It was thought to be extirpated from Massachusetts until the species was rediscovered on Cape Cod in 1980 and on Marthas Vineyard in 1994. None is currently extant on Nantucket or inland from Cape Cod. A large population occurs on a serpentine barren in Maryland, discovered in 1950, and reconfirmed in 1984. Montauk, Long Island, New York once harbored "untold millions" of *A. acuta* plants. It was thought to be extirpated from New York, but was rediscovered on Long Island and now is known from 12-13 EO's due to a combination of discoveries and restoration efforts (NatureServe 2011).

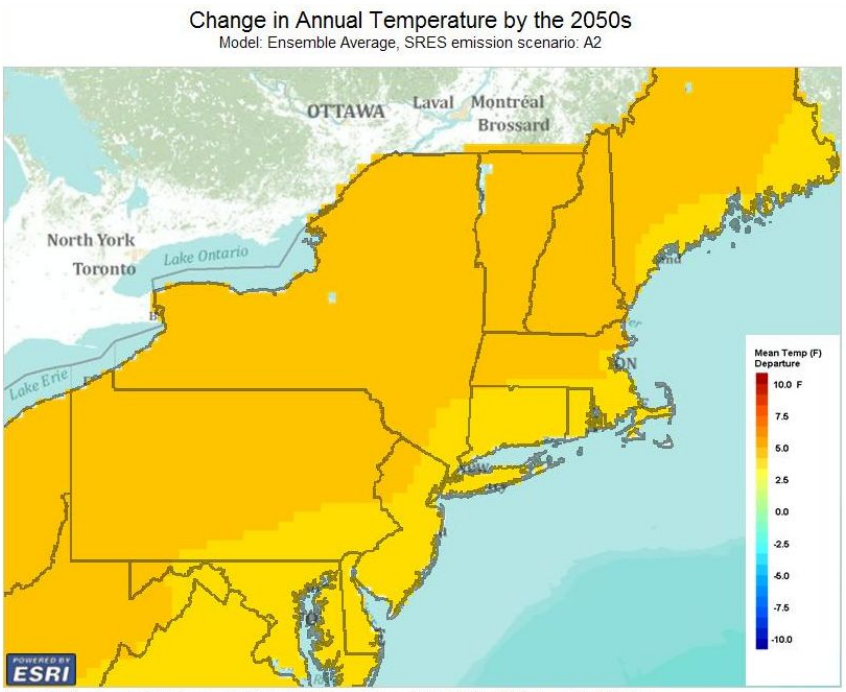
Cape Cod National Seashore Boundary

Sandplain Gerardia Exposure Assessment Tools

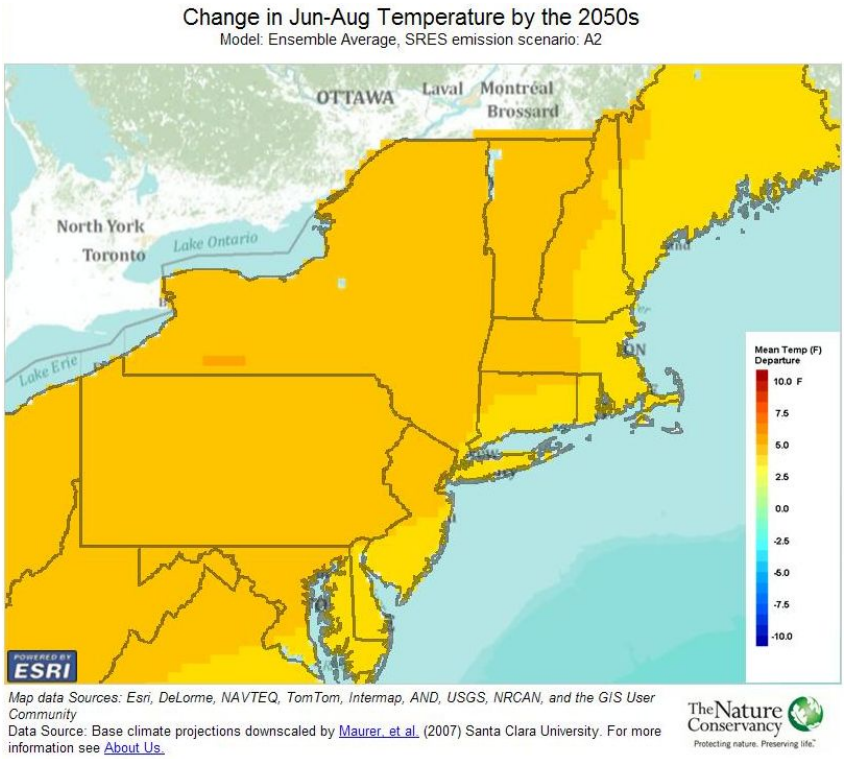
Topography



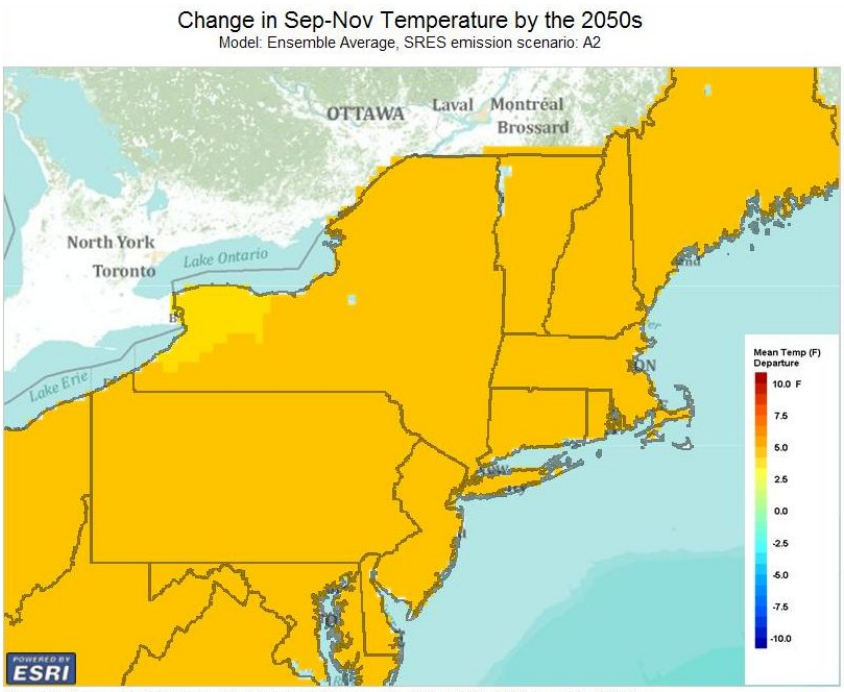
Annual temperatures



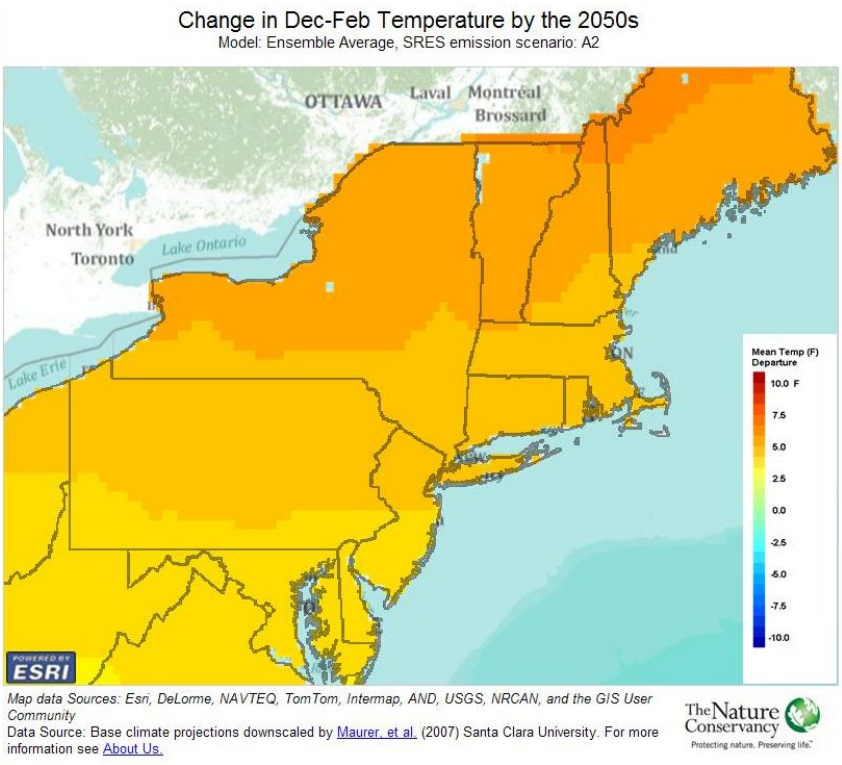
Summer temperatures



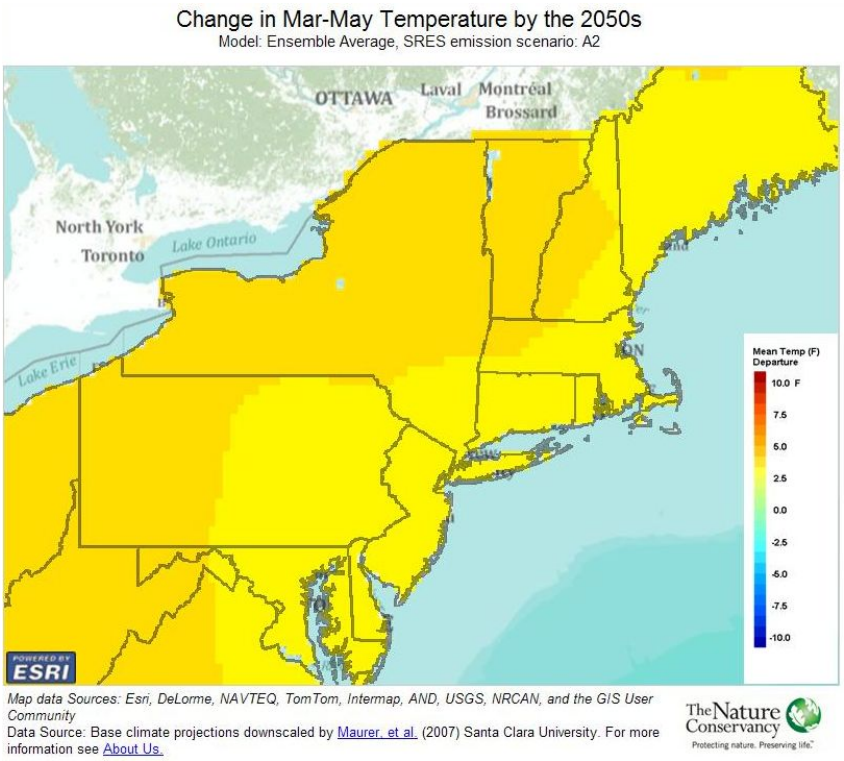
Fall temperatures



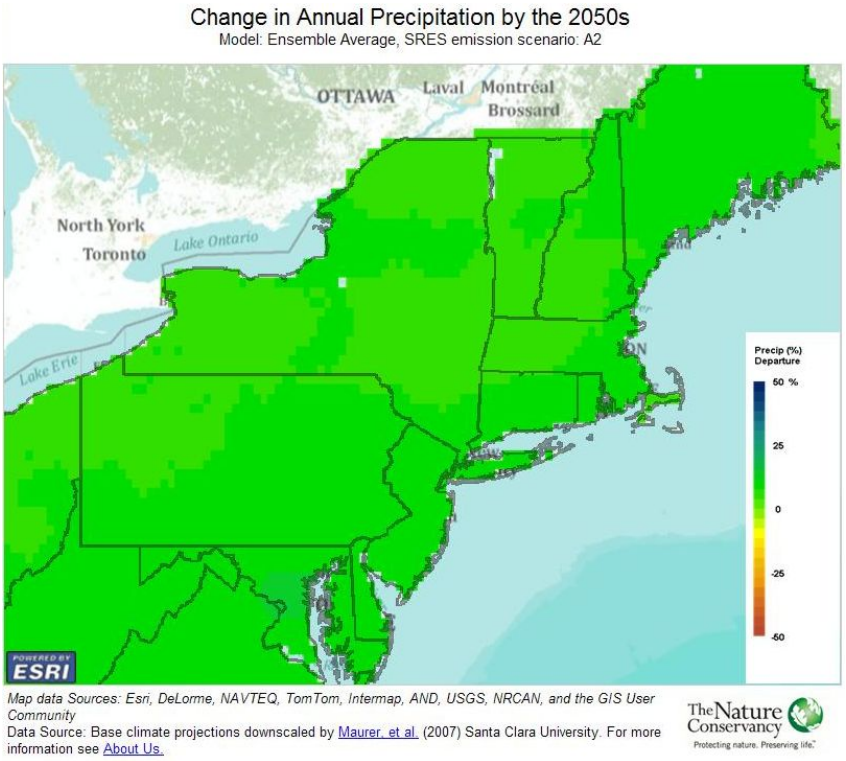
Winter temperatures



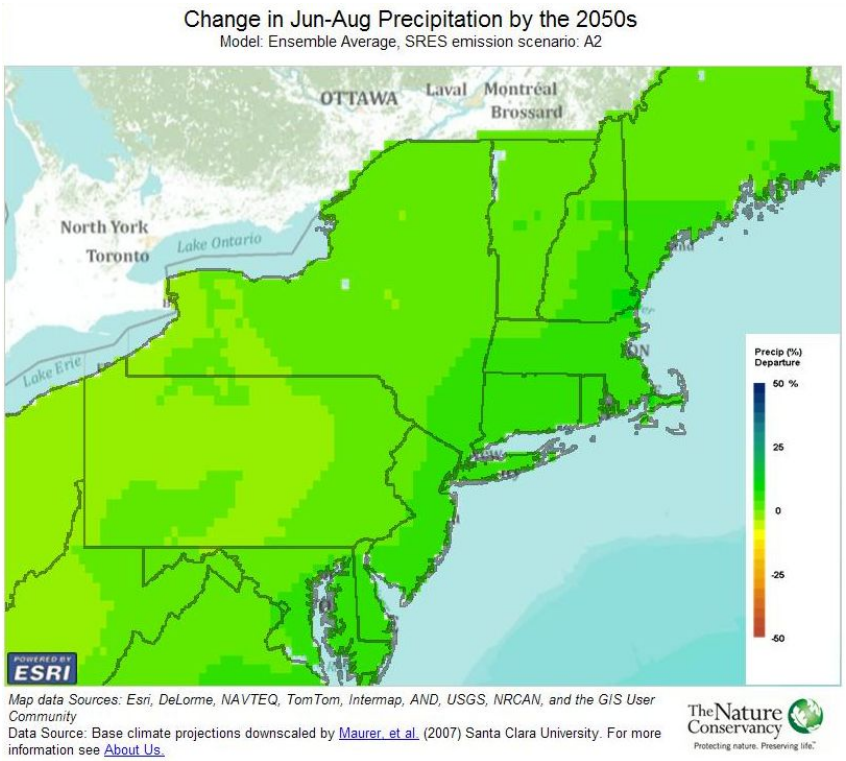
Spring temperatures



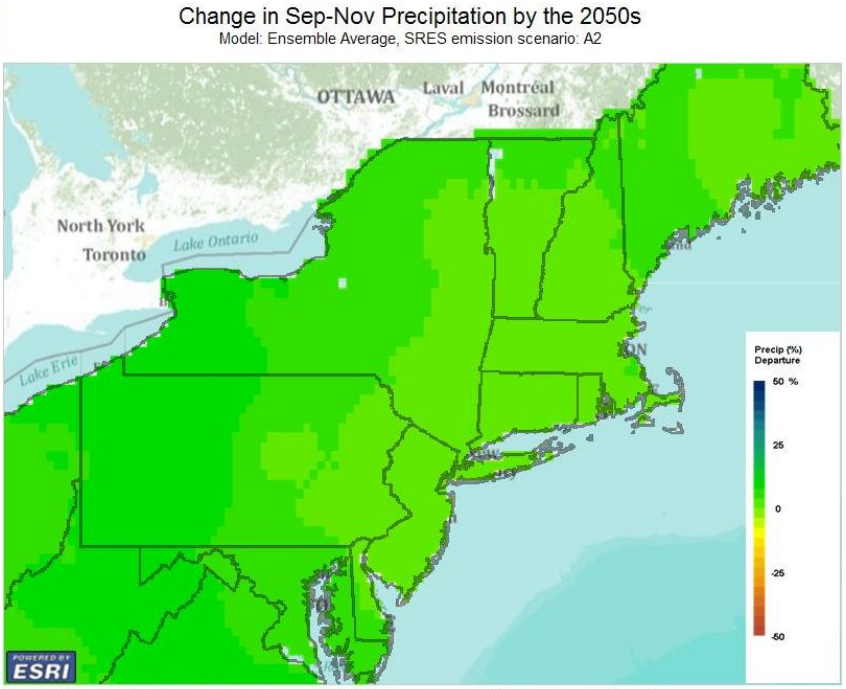
Annual precipitation



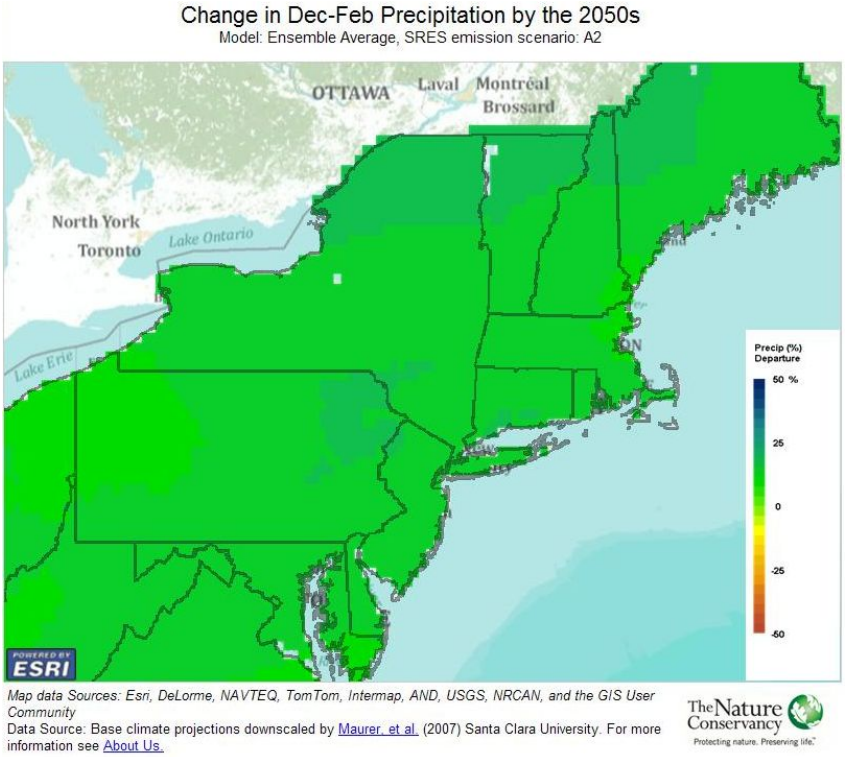
Summer precipitation



Fall precipitation

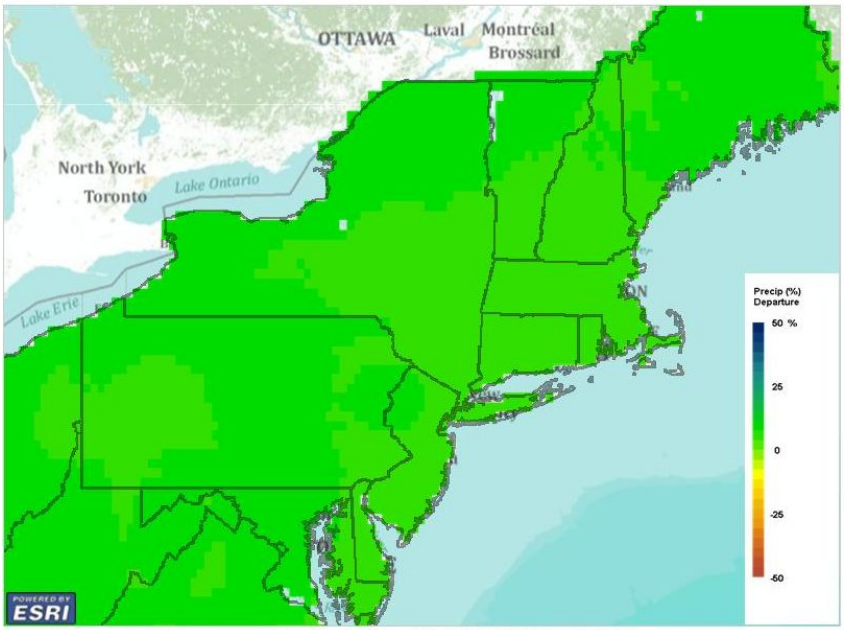


Winter precipitation



Spring precipitation

Change in Mar-May Precipitation by the 2050s
Model: Ensemble Average, SRES emission scenario: A2

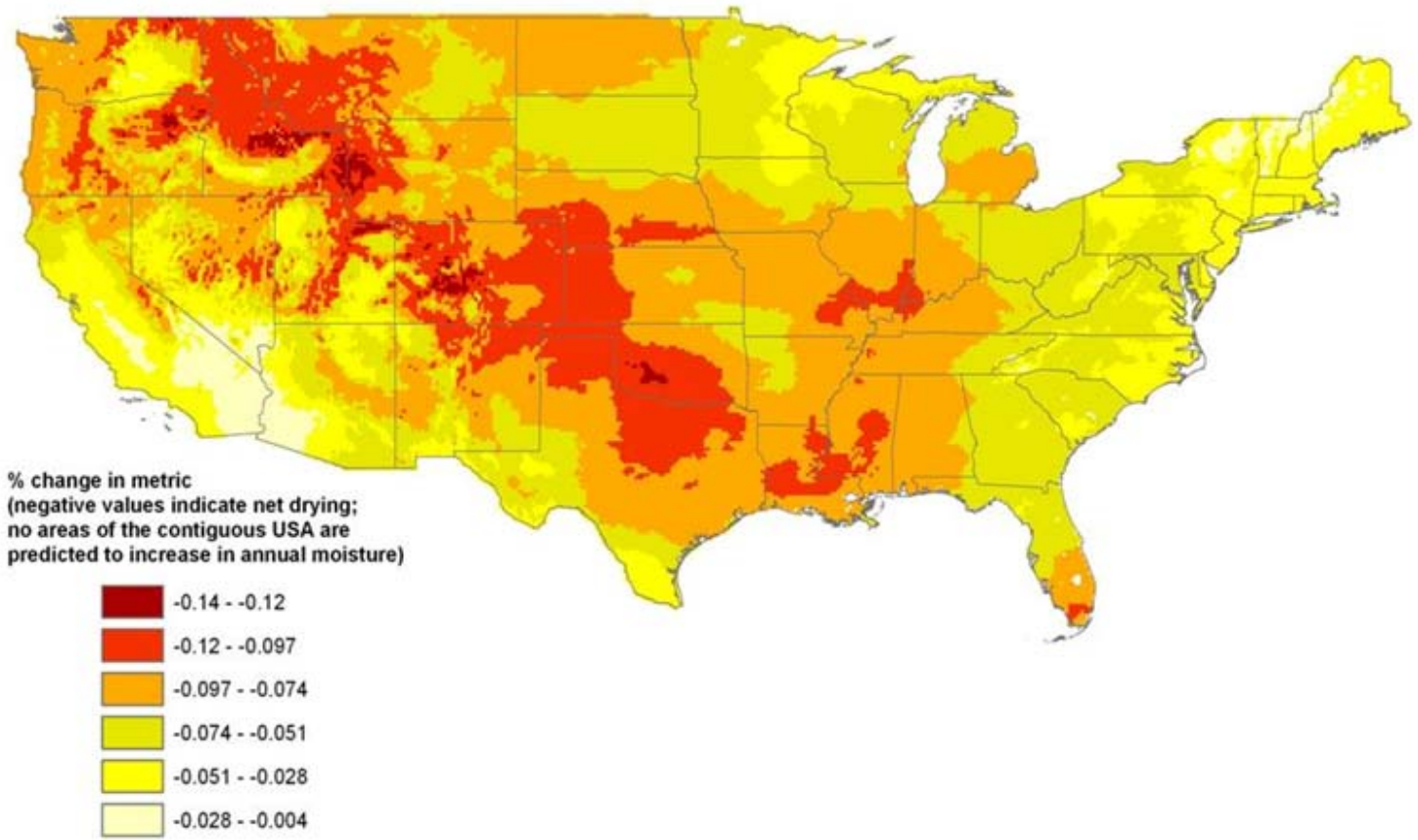


Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

The Nature Conservancy
Protecting nature. Preserving life.

Predicted Annual Change in Hamon AET:PET Moisture Metric, 2040-2069

Medium emissions A1B, 16-model ensemble average
based on ClimateWizard.org analysis



Exercise 2.3: Adaptive Capacity and Assessing Vulnerability

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group

In this exercise, we're asking you to think about the ability of species and habitat/administrative units to respond to climate change in ways that minimize its negative effects. Remember, don't get too caught up in whether you'd categorize a particular characteristic as adaptive capacity vs. exposure or sensitivity; the key is to think about vulnerability from a number of angles.

Output:

1. A measure of adaptive capacity for your species and your administrative unit
2. An overall vulnerability score/ranking for your species and administrative unit. Do this by pooling the results of your sensitivity, exposure, and adaptive capacity analyses in a way that makes sense to you. This could be qualitative or quantitative, spatial or numeric, it's up to you. Just be ready to defend your choices!

Resources:

I. Species/place information from the Sensitivity Exercise
II. Highways map
III. Pollution sources map (Air Releases, Superfund National Priorities List Sites, Toxics Release Inventory, Water Discharge Permits; (created using the National Atlas; can go to nationalatlas.gov and look at the "environment" layer if you want to zoom in)
IV. GAP protected areas map

Questions to consider:

Species:

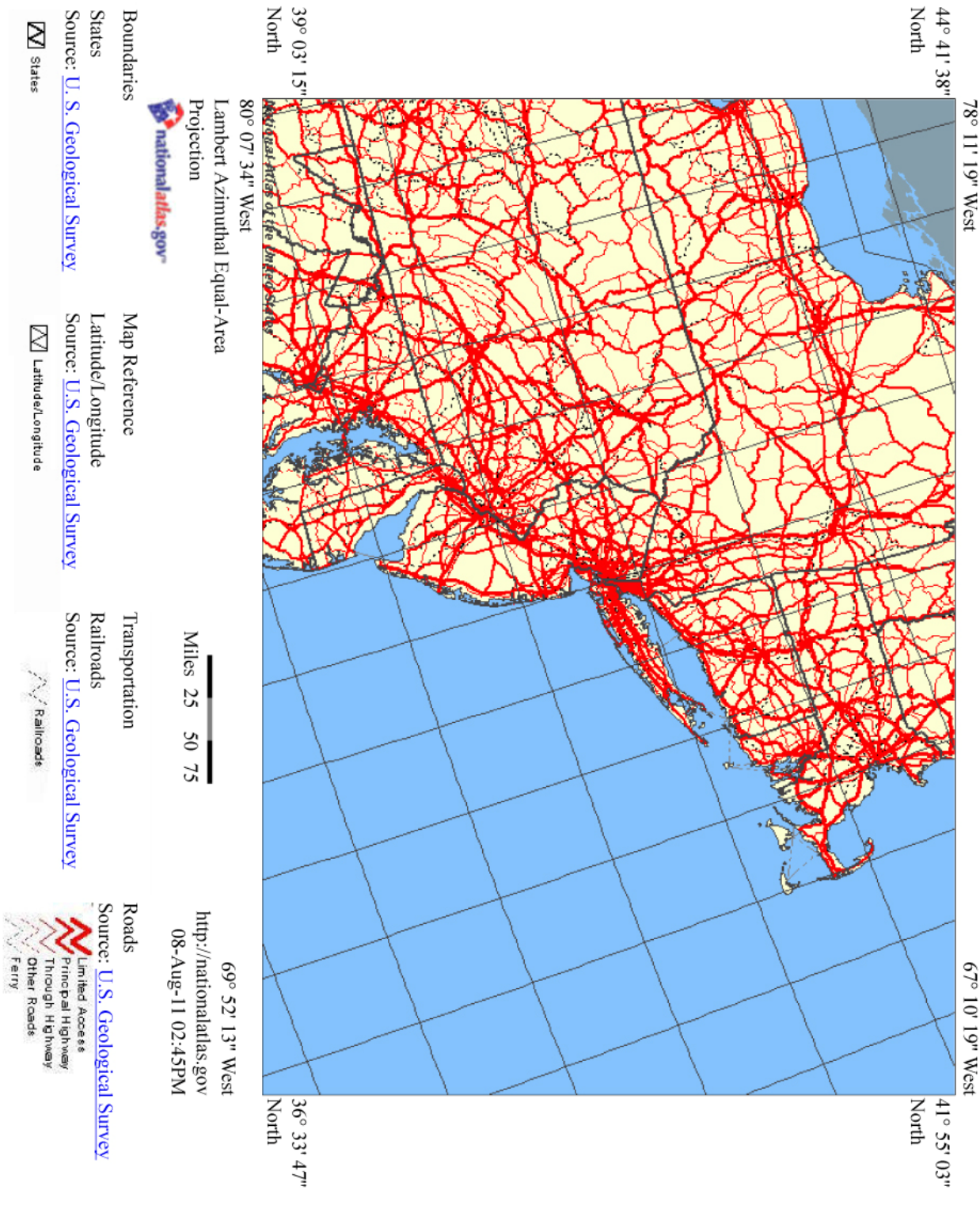
- Is its evolutionary rate fast? Slow? Somewhere in between?
- Roughly speaking, is there sufficient genetic diversity or availability of favorable alleles within the species to support evolutionary adaptation?
- Are individuals in this species capable of phenotypic adjustment in response to changes in their environment?
- Is there evidence that this species is already adjusting/adapting to change (e.g. shifting behavior, range, host plants, etc.)?
- Is the geography, land use, etc. such that it would be possible for individuals to seek out refugia during times of particular climate stress (e.g. prolonged heat wave)?
- Is the geography, land use, etc. such that it would be possible for species range shift to occur? Remember that species' range shifts typically happen by differential survival and reproduction, not by the purposeful movement of individuals to new locations.
- Are there multiple populations with enough connectivity among them to allow for rescue effects and gene flow?

Administrative unit/habitat:

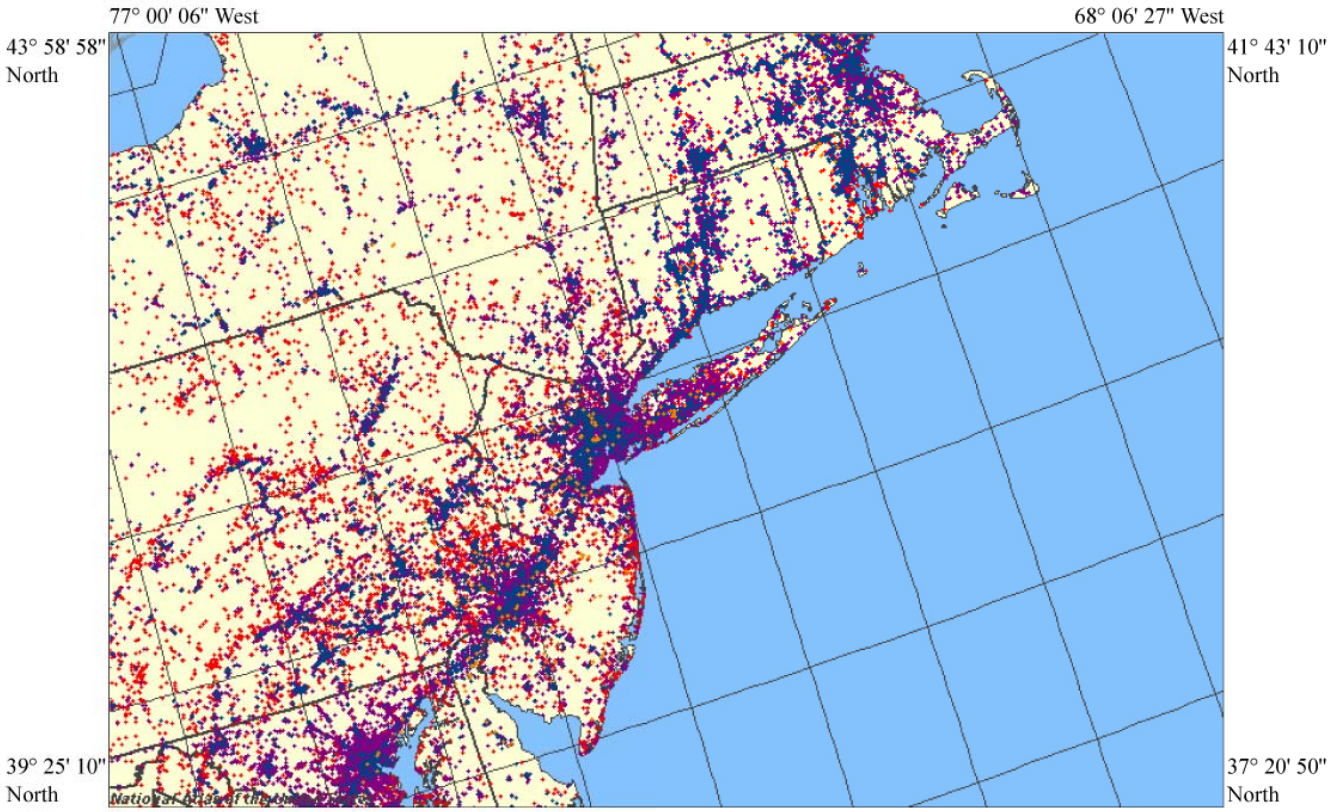
- What are the defining characteristics of the habitat community, and how vulnerable are they to climate change? E.g. presence of particular minerals in the soil may not be affected by climate change, whereas presence of vernal pools may be heavily affected.
- Is there a diversity of species in each functional group within the community/habitat?
- Is the geography, land use, etc. such that it would be possible for the community/habitat to shift location over time?
- Are there microclimates within the area that could support refugial communities?
- What is the nature of people's relationship to this habitat/community? Does it occur in areas where there is strong development pressure? Do people value this habitat because of services it provides (e.g. clean water, hunting or fishing opportunities, etc.)?
- Consider adaptive capacity of species and habitats within the unit.
- How rigid/specific are the rules governing management of the unit (e.g. for National Parks, what is in the enabling legislation)?
- Is there a General Management Plan or something similar? If so, how does this affect the adaptive capacity of the unit?

Sandplain Gerardia Adaptive Capacity Assessment Tools

Roads



Environmental Risk Sites



Boundaries

States
Source: U. S. Geological Survey

States

Environment

Water Discharge Permits
Source: U.S. Environmental Protection Agency

Water Discharge Permits

Air Releases
Source: U.S. Environmental Protection Agency

Air Releases

Toxics Release Inventory
Source: U.S. Environmental Protection Agency

Toxics Release Inventory

Superfund National Priorities List Sites
Source: U.S. Environmental Protection Agency

Superfund National Priorities List Sites

Map Reference

Latitude/Longitude
Source: U.S. Geological Survey

Latitude/Longitude

Protected Areas in Sandplain Gerardia range